Single Photon Imaging of Kidneys (Yesterday) Today and Tomorrow

R.K.Halkar MD
Andrew Taylor MD
Emory University Hospital
Atlanta- Georgia
Disclosures

- ELGEM - Royalties
- GE, CV therapeutic, Covidien – research and educational grants
- Philips - speaker
Objectives and Method

- Radiopharmaceuticals for imaging
- When to use what?
- Pharmacologic interventions in single photon imaging of kidney
- Case based approach to identify pitfalls
- Computer assisted diagnosis
Is there a future for radionuclide imaging of kidneys?

MR Urography
CT Urography
Ultra sound
Nuclear Medicine: Phoenix

We come back

Mark Twain: The news of my demise has been greatly exaggerated.
## Where we stand?

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>Cheap, no radiation</td>
<td>Only anatomy, operator dependent</td>
</tr>
<tr>
<td>CT Urography</td>
<td>Excellent anatomy, speed</td>
<td>Radiation, contrast is not physiologic</td>
</tr>
<tr>
<td>MR Urography</td>
<td>Excellent anatomy, physiology – No radiation</td>
<td>Slow speed, NSF</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Quantitation, Physiology</td>
<td>Poor spatial resolution</td>
</tr>
</tbody>
</table>
NSF (Nephrogenic Systemic Fibrosis)

Reported in 1997
Patient with GFR of less than 15 ml/min – Severely debilitating
Relation with NSF and Gd was announced by FDA
Renal disease in the United States

• 19 million people in the US are already in the early stages of renal disease and many don’t know it

• Early renal disease: GFR < 60 mL/min/1.73 m²

• By 2030, an estimated 2 million people in the US will need dialysis

Nephron Function

Renal blood flow 1200ml/min

RPF=600ml/min
GFR=120ml/min
Fil Fraction=0.2

Clearance of DTPA, EDTA and Inulin = GFR

Clearance of OIH = ERPF
<table>
<thead>
<tr>
<th>Radiopharmaceuticals for imaging</th>
</tr>
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<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Tc – MAG3</td>
</tr>
<tr>
<td>Tc-DTPA</td>
</tr>
<tr>
<td>Tc -DMSA</td>
</tr>
<tr>
<td>Tc-GH</td>
</tr>
<tr>
<td>I-131 OIH</td>
</tr>
</tbody>
</table>
New Radio pharmaceuticals

- Tc99m – EC
- Not lot of experience
Who are our customers? And what do they want?

• Majority = Urologists
  – Split function, assessment of dilated collecting system, Residual urine volume

• Minority = nephrologists, Intervention radiologists, ObG, Transplant surgeon
  – GFR, RVH assessment, renal blood flow
Do Not Just Interpret Images!!!
Answer a Clinical Question

• Tailor the exam - reduce imaging time
• What is the clinical question?
  – Split function - 5 min imaging is enough
  – Dilated collecting system - diuretic renography
• What is the creatinine level?
  – RVH if high creatinine do baseline and ACEI study
  – If Cratinine is normal – do ACEI first
What are the strengths/weakness of Radio nuclide technique

• True tracer kinetics
  – Tracer does not change the system
  – Iso-Ph, Isotonic, small volume
• Good IV bolus (infiltration gives spurious results)
• Hydration
• Radiopharmaceutical quality
Dose = 10.0 mCi MAG3
1 sec/frame  60
30 sec/frame  40

sec/Frame Perfusion Image
QC

Check for infiltration
Check for ROI
Check for time of arrival of bolus
Why and What and How split function?

- To save a kidney or not to save a kidney
- DMSA – 2 hour image
- MAG3 and DTPA use 2-3 minute image
- Factors that affect the split function measurement
  - ROI over kidney, Background
  - Timing (2-3 minute)
  - Location of the kidney (diff attenuation)
Left: 46%
Right: 54%
Left: 1%
Right: 99%
# Normal Ranges

MAG3 clearance = 304 ml/min  
(226 - 439)

<table>
<thead>
<tr>
<th>kidney</th>
<th>Left</th>
<th>Right</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>&amp; uptake</td>
<td>46</td>
<td>54</td>
<td>(45 - 58)</td>
<td>(42 - 55)</td>
</tr>
<tr>
<td>Tmax (min)</td>
<td>9.8</td>
<td>4.8</td>
<td>(2.3 - 6.8)</td>
<td>(2.3 - 9.8)</td>
</tr>
<tr>
<td>T1/2 (min)</td>
<td>6.0</td>
<td>&gt;50</td>
<td>(3.7 - 10.5)</td>
<td>(4.0 - 17.0)</td>
</tr>
<tr>
<td>2D/max</td>
<td>0.22</td>
<td>0.59</td>
<td>(0.13 - 0.35)</td>
<td>(0.12 - 0.54)</td>
</tr>
<tr>
<td>postvoid/max</td>
<td>0.05</td>
<td>0.24</td>
<td>(0.05 - 0.15)</td>
<td>(0.03 - 0.16)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>cortical</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tmax (min)</td>
<td>3.0</td>
<td>4.1</td>
<td>(2.1 - 3.3)</td>
<td>(2.1 - 3.6)</td>
</tr>
<tr>
<td>T1/2 (min)</td>
<td>8.8</td>
<td>8.8</td>
<td>(3.8 - 7.3)</td>
<td>(3.3 - 8.8)</td>
</tr>
<tr>
<td>2D/max</td>
<td>0.19</td>
<td>0.38</td>
<td>(0.13 - 0.27)</td>
<td>(0.12 - 0.34)</td>
</tr>
</tbody>
</table>

| voided vol.  | 100 ml |       | (50 - 500) |       |
| residual vol.| 7 ml   |       | (5 - 36)   |       |
| urine flow   | na     |       |            |       |

Esteves et al. AJR 187: December, 2006
Voided volume: 100 mL
Residual volume: 7 mL (5-36 mL)

Esteves et al. AJR 187:W1-W13, 2006
Background Correction
Mean % uptake in the phantom kidney


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Test Case 1

- 87 year old male in great shape with right renal mass
- Renogram for split function prior to surgery
- The study was repeated after 3 days
L: R = 61: 39

Renogram Review

- Patient height: 105.0 cm
- Patient weight: 81.0 kg
- Patient age: 87 y.o. mna
- Dose injected: 10.51 mCi
- Dose counted: 1.40 mCi
- % infiltrated: 0.00
- NaNa clearance: 307 ml/min
- Expected Cr: 150 ml/min

Kidney: Left Right

- % uptake: 61 39
- T1/2 (min): 11.0 >50
- 2b/max: 0.30 0.97
- Voided vol.: na
- Residual vol.: na
- Urine flow: na

Case 1
Day 1

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L : R = 51:49

<table>
<thead>
<tr>
<th>Patient Height</th>
<th>185.0 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Weight</td>
<td>83.0 kg</td>
</tr>
<tr>
<td>Patient Age</td>
<td>87 yrs. M</td>
</tr>
<tr>
<td>Dose Injected</td>
<td>10.47 mCi</td>
</tr>
<tr>
<td>Dose Counted</td>
<td>1.33 mCi</td>
</tr>
<tr>
<td>% Infiltrated</td>
<td>0.00</td>
</tr>
<tr>
<td>Neph clearance</td>
<td>117 ml/min</td>
</tr>
<tr>
<td>Expected Clear</td>
<td>150 ml/min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kidney</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>% uptake</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>T1/2 (Min)</td>
<td>3.8</td>
<td>23.3</td>
</tr>
<tr>
<td>20/Max</td>
<td>0.76</td>
<td>0.97</td>
</tr>
</tbody>
</table>

| Voided Vol. | na   |
| Residual Vol.| na   |
| Urine Flow  | na   |

Case 1  Day 4
What is the cause for difference in split function?

- Change in renal function
- Wrong Isotope was used
- Improper Background correction
- Dose infiltration
- Software bug
Test Case 2: 45 year old male

- Had avulsion of left renal artery
- Transplantation of kidney in the left iliac fossa.
- Now has tumor in the transplanted kidney
- Creatinine is 1.2
**Patient Information**

- **Age:** 49 years
- **Height:** 170.18 cm
- **Weight:** 72.72 kg
- **Radiopharmaceutical:** IcMAG3
- **Injected dose:** 10.87 mCi
- **Counted dose:** 1.24 mCi
- **BSA:** 1.44 m²

**Blood Flow Results**

<table>
<thead>
<tr>
<th>Radiotracer</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney Area (cm²)</td>
<td>76.52</td>
<td>65.70</td>
</tr>
<tr>
<td>Kidney depth (cm)</td>
<td>7.29</td>
<td>7.47</td>
</tr>
<tr>
<td>Perfusion (mL/min/100g)</td>
<td>23.72</td>
<td>76.28</td>
</tr>
<tr>
<td>Perfusion% (Slo)</td>
<td>29.93</td>
<td>70.07</td>
</tr>
<tr>
<td>Uptake% (Int)</td>
<td>10.55</td>
<td>81.45</td>
</tr>
<tr>
<td>MAG-CL</td>
<td>39.97</td>
<td>175.46</td>
</tr>
</tbody>
</table>

**Time to Peak**

- **Time to 1/2 peak:** 3.82 min, 1.15 min
- **Time to peak:** 17.8 min, 3.64 min
- **Peak to 1/2 peak:** 29.86 min, 5.41 min
- **20min/peak ratio:** 0.97, 0.21
- **20min/3min ratio:** 2.4, 0.25

**Cortex**

- **Time to 1/2 peak:** 1.93 min, 0.72 min
- **Time to peak:** 3.54 min, 2.17 min
- **Peak to 1/2 peak:** 7.51 min, 3.68 min
- **20min/peak ratio:** 0.76, 0.2
- **20min/3min ratio:** 1.11, 0.23

**Graphs and Images**

- Perfusion 0-30s
- Blood flow curves
- Comparative images of left and right kidneys
- Comparative images of cortex and bladder

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The report will say

• Split function is Left : Right = 19: 81
• MAG3 clearance is accurate
• Sacrifice left kidney
• Split function is incorrect
Split function with geometric mean Left:Right = 48:52
How and why Geometric mean?

• Geometric mean = $\sqrt{\text{Anterior cts} \times \text{Posterior cts}}$

• To account for different depth and attenuation.
• Geometric mean corrects better than arithmetic mean
Assessing a dilated collecting system

- Whittaker’s test –gold standard – invasive
- O’Reiley started the diuretic renography
- F-15, F+, F-20
- Hydration
- T1/2 =/< 10 minute = No Obstruction
- T1/2 >20 minutes = Obstruction
- T1/2 =10-20 minutes = Indeterminate study
Issues in diuretic renography

- Is it needed or not
- Post void image may clear almost all the tracer
- Dose of Lasix?
- When to give Lasix?
- To catheterize the bladder or Not
Factors that cause false positive diuretic study

- Infiltrated dose
- Dehydration
- Full bladder
- Reflux
- Large renal pelvis
Left Flank pain
U/S- dilated collecting system

Pre op – Lasix study
POST OP

Age: 50, Years
Height: (cm): 157
Weight: (kg): 74.5
Radiopharmaceutical: Tc99m DMSA
Injected dose: (mCi): 10.52
Counted dose: (mCi): 0.65
BSA (m^2): 1.54

MAG-CL (ml/min) 166.33
Expected MAG-CL (ml/min) 240.84
Equil GFR-CL (ml/min) 501.92
Expected ORN-CL (mL/min) 480.74

Kidney

Left
Right

Kidney size (cm^2) 67.85 77.26
Depth (cm) 6.82 6.29
Perfindex (Hill) 109.17 213.51
Perfusion% (int) 58.09 49.61
Perfusion% (t) 73.54 79.30
Uptake% (int) 45.61 54.39
MAG-CL 75.86 90.47

Time to 1/2 peak 1.40 1.62
Time to peak 16.02 18.68
Peak to 1/2 peak 19.68 20.68
20min/peak ratio 0.79 0.79
20min/3min ratio 1.2 1.2

Cortex

Left
Right

Time to 1/2 peak 0.19 0.19
Time to peak 2.86 2.86
Peak to 1/2 peak 9.38 9.38
20min/peak ratio 0.35 0.35
20min/3min ratio 0.37 0.37

The images depict various medical scans and graphs, likely related to renal function or uptake, with measurements and metrics indicated.
Proof of pudding: Is diuretic renography reliable?
One year later
Case 3: 57 yr old man s/p cystoprostatectomy

- Adenocarcinoma of prostate
- Indiana pouch for 2 years
- Left hydronephrosis by US
- Serum BUN and Creatinine in the normal range
- Diuretic renogram was requested
Renogram

Post Lasix (40 mg)

Case 3: \( T_{1/2} = 19 \) minutes
What is your diagnosis?

A. No evidence of obstruction in both kidneys
B. Urinary leak on the right side
C. Dose of Lasix is inadequate - repeat with higher dose of Lasix.
D. Indeterminate left kidney – repeat with an indwelling catheter in the diversion
E. Both kidneys are obstructed
Renogram With Foley in the pouch

Post Lasix (40mg)

Case 3:

\[ T_{1/2} = 9.9 \text{ minutes} \]
Types of Urinary Diversion

Continent

Ileal Conduit  Indiana Pouch  Neo Bladder
Diuretic Renography: Causes for False positives

- Reflux
  - Continent diversion often have reflux
- Full bladder
- Poor renal function
- Reservoir effect due to large pelvis
Renovascular Hypertension (RVH)

- Afferent Arteriole
- Efferent Arteriole
- Glomerulus
- Proximal Tubule
- GFR Normal
Functionally Significant Renal Artery Stenosis (RVH)

Decrease in perfusion pressure to the afferent arteriole and release of renin

Angiotensin II causes vasoconstriction of the efferent arteriole

GFR Maintained

Glomerulus

Proximal Tubule
Renal Artery Stenosis

- Afferent Arteriole
- Efferent Arteriole

Filtration pressure
GFR reduced

ACE-Inhibitors block production of A-II and the breakdown of bradykinin dilating the efferent arteriole and reducing the transglomerular pressure gradient.

GFR Reduced
Proximal Tubule

Functionally Significant

GFR Reduced

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ACEI Renography

Rationale: ACEI renography can identify hypertensive patients with RAS who will benefit from revascularization and identify patients with low likelihood of disease.

• 10 ACEI studies with outcome recorded
• 291 patients with positive ACEI exam
• 268/291 (92%) improved or cured

Taylor A. Seminars in Nephrology 20:437, 2000
ACE - Inhibitors

• Captopril: 25-50 mg
  – Most commonly used ACE inhibitor.
  – Crush tablet and administer with water
  – Wait an hour prior to tracer injection

• Food can interfere with absorption
  – Enalaprilat (IV Vasotec): 0.04 mg/kg, max 2.5 mg
  – Wait at least 15 min prior to tracer injection
  – Establish IV line in case of hypotension

ACE Inhibition Protocols

• Baseline plus ACE inhibition acquisition
  – 1-2 mCi for the baseline exam
  – MAG3 and DTPA both acceptable
  – Give ACE inhibitor and repeat study with 8-10 mCi.
  – Faster clearance of MAG3 may result in less interference from baseline study
  – MAG3 recommended in patients with reduced function

• Begin with ACE inhibition acquisition
  – If normal, study is complete.
  – If abnormal, patient may need to return for a baseline exam.

Taylor et al. SNM Procedure Guideline on RVH. www.snm.org
Interpretation

- High probability ( > 90%)
- Intermediate probability
- Low probability ( < 10%)

Taylor et al. SNM Procedure Guideline on RVH. www.snm.org
Renovascular Hypertension

MAG3 baseline images. Sequential 2-min images obtained in posterior projection.
Renovascular Hypertension

MAG3 administered 1.5 hours post-captopril
Case 4: 22 yr old woman

• Hypertension – on antihypertensives
  – Baseline BP 126/78
• Not on ACE inhibitors
• Baseline and ACEI renogram was requested
Case 4: Baseline

RP: 2.0 mCi Tc-99m MAG3
MAG3 Clearance: 268 ml/min (expected = 281 ml/min)
RP: 10.0 mCi
MAG3 Clearance: 29ml/min
ACEI: 2.5 mg of Enlaprilat

Case 4: Post ACEI

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Baseline
L:R=50:50
Cl:268ml/min
Rt20/2-3

Post ACEI
L:R=67:33
Cl=29ml/min
Question: What is your Diagnosis?

A. High Probability of Renovascular hypertension
B. Intermediate Probability for RVH
C. Low probability of RVH
D. Dose of ACEI is wrong
E. Repeat the study because of technical problems.
ACEI study repeated with 2.5 mg of Enalaprilat after 6 days
RP : 10.0mCi of Tc-99m MAG3

Case 4 : repeat Post ACEI
Inadvertent administration of Tc04

- Free Tc04 in the stomach
- The post ACEI curves do not have the normal parenchymal uptake phase
- They appear more like a blood pool activity
Transplant

- Vascular problem, Acute Rejection, ATN, Ureteric obstruction, Urinoma, seroma
- Cadaver kidney – ATN
- Anterior projection for imaging
Case 5

• 15 day s/p live related donor transplant
• Low urine output
• Increasing creatinine
Case 5

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What is your Diagnosis?

• A. ATN
• B. Acute rejection
• C. High grade Obstruction- needs diuretic renography
• Needs delayed images – for possible RVThrombosis
The correct answer is: 2 hour delayed images and RVThrombosis

Case 5
Renal Clearance

• UV/P
• units are ml/min
• Often used by nephrologists
• Renal clearance of DTPA, Inulin = GFR (120ml/min)
• Renal clearance of OIH = ERPF (600ml/min)
• Renal clearance of Tc-99m MAG3 = ERPF/0.6 (320ml/min)
Clearance Measurements

• Plasma sample clearances
  – Plasma sample at 45 min (MAG3) or 3 h (DTPA)

• Camera-based clearances
  – Gates Technique: GFR/DTPA
  – QuantEM™: MAG3

• MAG3 camera-based clearance reflects creatinine clearance in wide range of renal function

Taylor et al. Radiology 204:47, 1997
Esteves et al. AJR 187: Dec, 2006
MAG3 Clearance

Q/C for Clearance

• Weight, Height and age and gender
• Bolus injection
• Time of arrival of the dose
• Renal ROI
• Background ROI
Reproducibility of MAG3 Clearance

• Creatinine clearance is the standard of care for assessment of change in renal function
• It has a poor reproducibility and collection of 24 hour urine is difficult
• We compared the reproducibility of MAG3 Clearance and Creatinine clearance
MAG3 Clearance by Camera based method has an excellent reproducibility

An Expert system to help interpret radionuclide renal studies

Radiation Dosimetry

- Low radiation dose from both MAG3 and DTPA

- Effective dose equivalent from MAG3 is about 25% lower than the dose from DTPA

- In hydrated patients with good renal function, about 70% of MAG3 reaches the bladder by 30 minutes

- Patients should always be asked to void after completion of a MAG3/DTPA study to minimize the radiation dose to the bladder and gonads

Pediatrics

• Dilated collecting system
  – Poorly developed glomerulus- MAG3 between DTPA – Lasix may not be effective in infants

• Pyelonephritis
  – Tc-DMSA

• Reflux
  – Radionuclide cystogram – voiding cystogram
Study Date: 4/30/2008

Series: DMSA STATIC [Series ROI And Curve] 4/30/2008

View: POSTERIOR

LT KIDNE 48621 cts.
RT KIDNE 47964 cts.
LT KIDNE 50.34 %
RT KIDNE 49.66 %
Ratio: 1.0137

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Summary

• Renal Physiology
• Acquisition, processing, interpretation of renal imaging - mainly in adults
• Clearance - Measurements
• Pit falls and how to prevent them
Case 6

- 67 year old male,
- Renogram was requested prior to a major abdominal procedure,
- The creatinine went up after the procedure.
- Renogram was repeated after the procedure.
Case 6

Renogram Review

- Patient height: 170.0 cm
- Patient weight: 82.0 kg
- Patient age: 69 y.o. male
- Dose injected: 10.47 mCi
- Dose counted: 1.34 mCi
- Infilt rate: 0.00 mCi/min
- M&G clearance: 159 ml/min
- Expected Clr: 209 ml/min

Kidneys: Left Right
- % uptake: 57 42
- Tmax (min): 12.3 12.3
- T1/2 (min): >50 >50
- 20/Max: 0.90 0.95
- Voided vol.: na
- Residual vol.: na
- Urine flow: na

2 sec/frame

2 min/frame

Postvoid kidney

Injection site

Dynamic cine

Prevoid

Postvoid

Graphs showing counts per minute and renal activity over time.
Case 6

QuantEM Review

Patient Height = 170.0 cm
Patient Weight = 82.0 kg
Patient Age = 69 y.o. male
Dose Injected = 10.47 mCi
%
Infiltrated = 0.00

MA63 Clearence = 11 ml/min
Expected Clr = 209 ml/min

Kidney: | Left | Right |
--------|-------|-------|
% Uptake | na    | 100   |
T_max (min) | na    | 9.3   |
T1/2 (min) | na    | >50   |
20/max     | na    | 0.65  |

Voided Vol. = na
Residual Vol. = na
Urine Flow = na

2 sec/frame

2 min/frame

Postvoid Kidney

Injection Site

Dynamic Cine

Prevaid

Postvoid

Slides are not to be reproduced without permission of author.
What was the procedure?

- A. Prostatectomy
- B. Lithotripsy
- C. Pyeloplasty
- D. AAA repair
The correct answer is

- D. AAA repair
Case:8

- 72 year old man with H/O prostate cancer
- S/P radiotherapy
- Bladder diverticulum
- Left sided hydrenephrosis
Case: 8

Renogram Review

- Patient height = 175.3 cm
- Patient weight = 69.1 kg
- Patient age = 72 y.o., male
- Dose injected = 10.25 mCi
- Dose counted = 1.45 mCi
- % infiltrated = 0.04
- NAC3 clearance = 156 ml/min
- Expected CLR = (228 - 423)

Kidney:
- Left
- Right

- % uptake = 1
- Tmax (min) = 23.0
- T1/2 (min) = 3.6
- 20/Max = 0.92

- Voided vol. = na
- Residual vol. = na
- Urine flow = na

Graphs showing counts per minute over time for both kidneys, with annotations for different time periods (2-3 min and 19-20 min) and kidney phases (prevoid and postvoid).
Diuretic Review

patient age = 72 y.o. male
tracer injected = 10.25 mCi
diuretic injected = 89.0 mg

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>kidney T1/2 (min)</td>
<td>100.0</td>
<td>54.0</td>
</tr>
<tr>
<td>pelvis T1/2 (min)</td>
<td>100.0</td>
<td>42.0</td>
</tr>
<tr>
<td>voided vol.</td>
<td>550 ml</td>
<td></td>
</tr>
<tr>
<td>residual vol.</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td>urine flow</td>
<td>na</td>
<td></td>
</tr>
</tbody>
</table>

2 min/frame

![Images of kidney scans]

![Graph of counts per minute vs time (Whole Kidney)]

![Graph of counts per minute vs time (Renal Pelvis)]

window %: UL = 100, LL = 0
What is the diagnosis?

A. Poor functioning left kidney with high grade obstruction
B. Bilateral obstruction
C. Left kidney shows vesicle ureteral reflux
D. None of the above
The correct answer is

C. Left vesico ureteral reflux. An indwelling catheter in the bladder during the renogram may help.
What about PET?

- N-13 H3 – for renal blood flow assessment
- GFR and RPF agents
- Other markers
Q.1. Causes for false positives in diuretic renography are all of the following except

A. Vesico – ureteric reflux
B. Infiltrated radiotracer
Dose
C. Large body habitus
D. Poor Renal function
Q.2. Split function can be altered by all of the following except

- A. Improper ROI over the kidneys
- B. Improper Background selection
- C. Starting the camera 2-3 minutes after the injection
- D. Dose infiltration
Q.3. MAG3 Clearance calculation by camera based method can be spurious due to the following except

- A. Dose infiltration
- B. Wrong height and weight recording
- C. Wrong ROI over the kidney
- D. Using less than 10.0mCi of Tc-99m MAG3
Q.4. All the following are correct for ACE inhibitor renography except

- A. Can be done as one day protocol
- B. Can be done as two day protocol
- C. Is more sensitive when the renal function is very poor.
- D. Oral or IV route can be used for administering the ACE inhibitor.
Q.5.

- 2 day post cadaver transplant
- Increasing creatinine
- Low urine output
What is your diagnosis?

• A. acute rejection
• B. ATN
• C. Ureteric reflux
• D. Urinoma causing obstruction
Answers

• Q.1. = C
• Q.2. = D
• Q.3. = D
• Q.4. = C
• Q.5. = B